



Federal
Communications
Commission

Part I:

Overview of OET-69 and *TVStudy* Software

Robert D. Weller

Chief, Technical Analysis Branch

[robert.weller @ fcc.gov](mailto:robert.weller@fcc.gov)

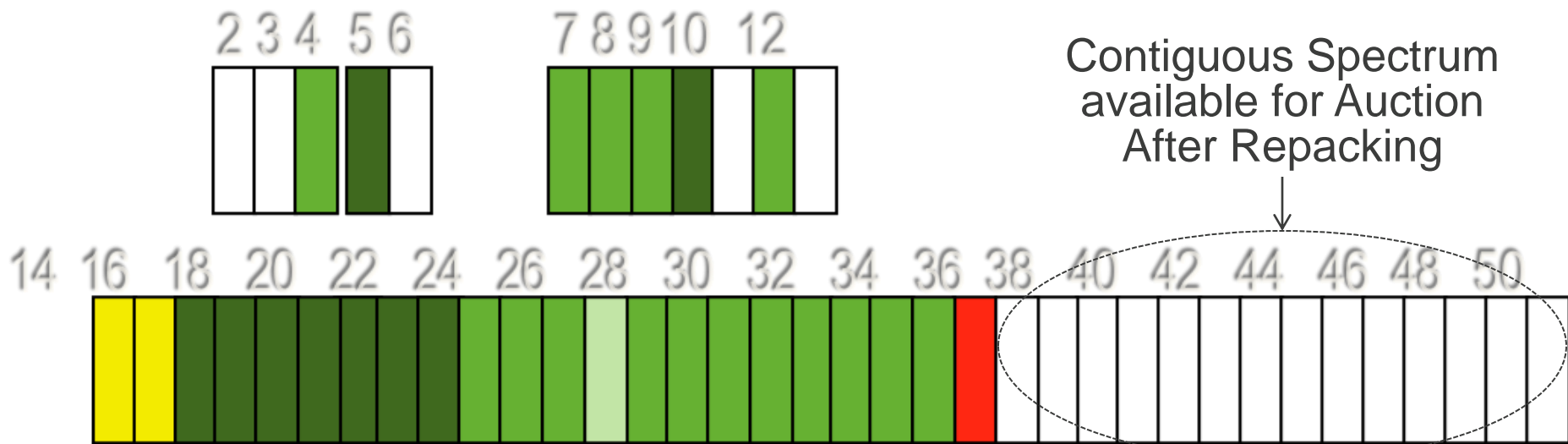
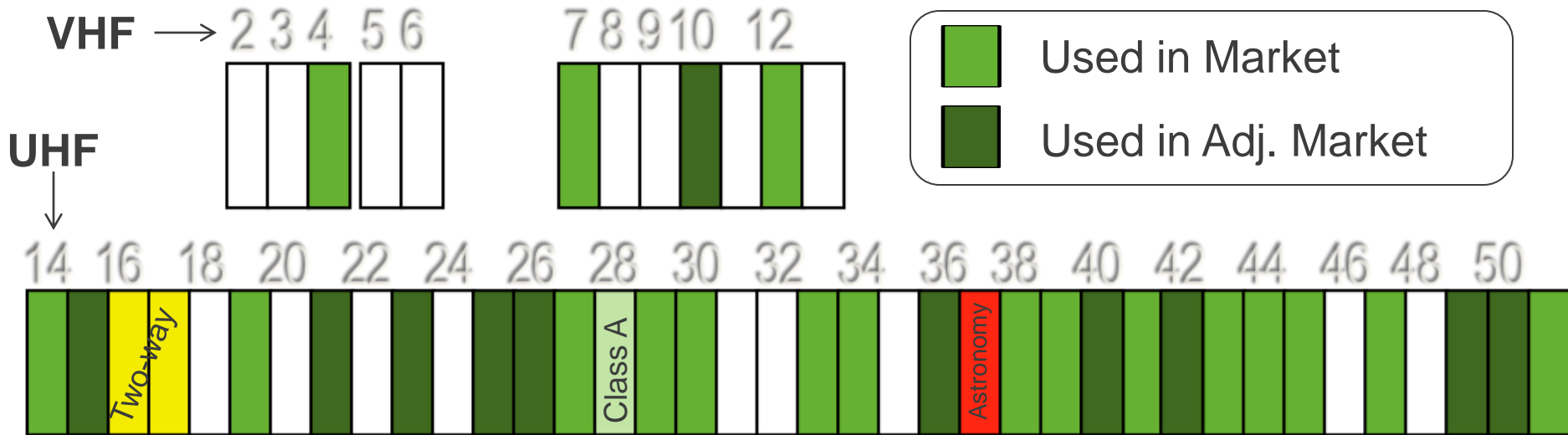
August 22, 2013

OET-69 and TVStudy Overview

- “Repacking” of Television Stations
- Allotment and channel reuse restrictions
- What is OET-69?
- Assumptions for Coverage Area and Population Served for illustrative study
- What is *TVStudy*?
- Station and Parameter selection for the illustrative study
- Illustrative output files for summarizing interference calculations



Repacking of Television Stations (Illustration)



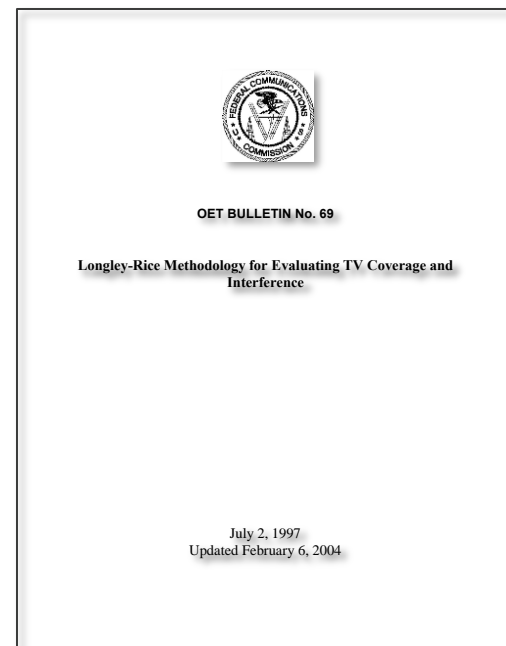


Channel Usage Restrictions to limit interference

- Co-Channel operation generally requires physical separation of transmitting locations
- Adjacent-Channel operation generally requires either physical separation or collocation
- OET-69 accounts for local terrain and other factors, which mean that the actual distances required to prevent interference could be greater or lesser than typical values that might be used for spacing-based allotments

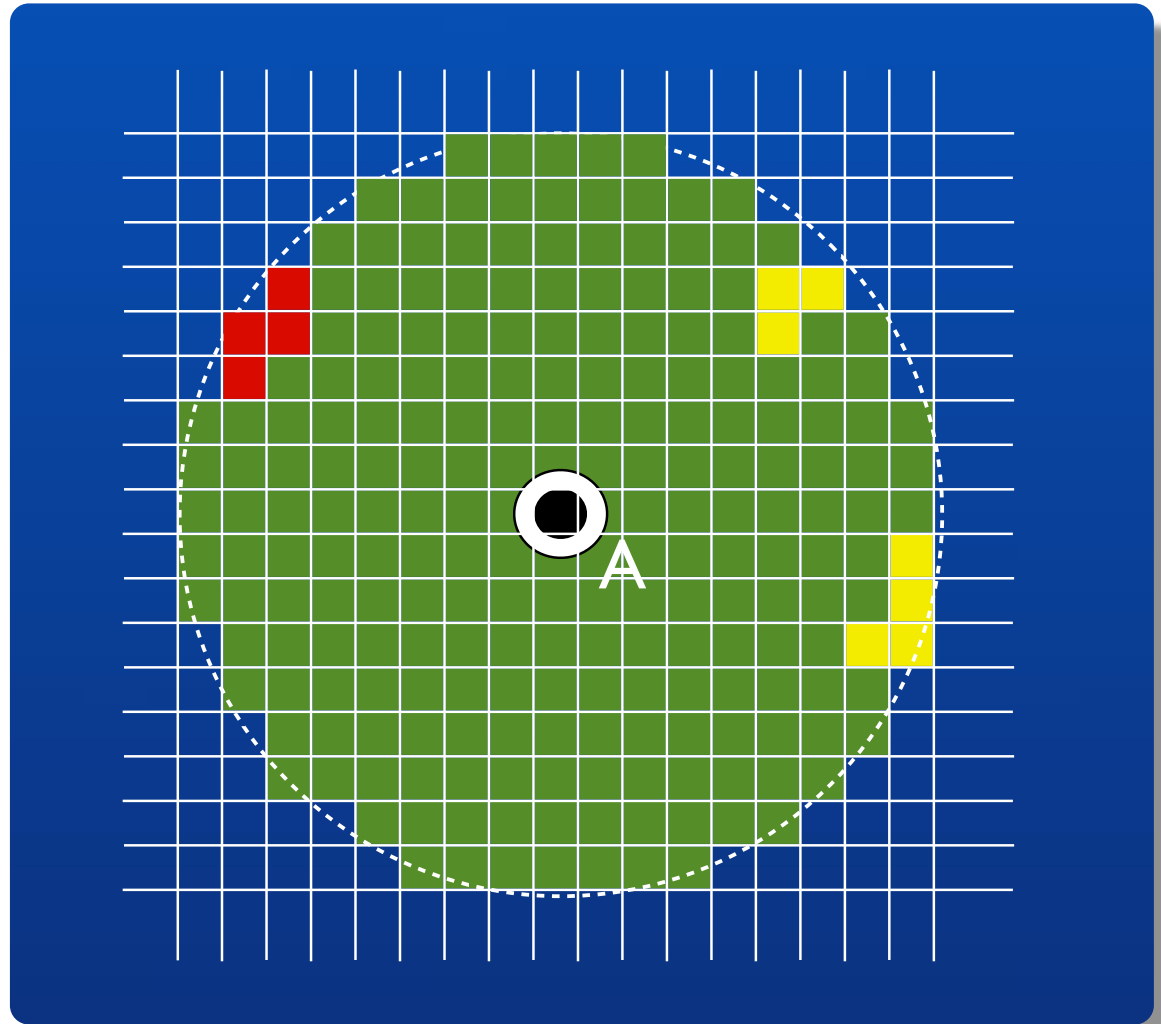
FC What is OET-69 ?

- “Longley-Rice Methodology for Evaluating TV Coverage and Interference”
 - Developed in 1990s for the transition from analog to digital
 - A methodology for determining coverage area and population served using two propagation models
- A Five-Step Process:
 1. Establish contour as limit of service
 2. Divide area within contour into square cells
 3. Determine whether coverage exists in each cell
 4. Check for interference in each coverage cell
 5. Sum population of all cells having interference-free coverage



FC What is OET-69 ?

Interfering
Station



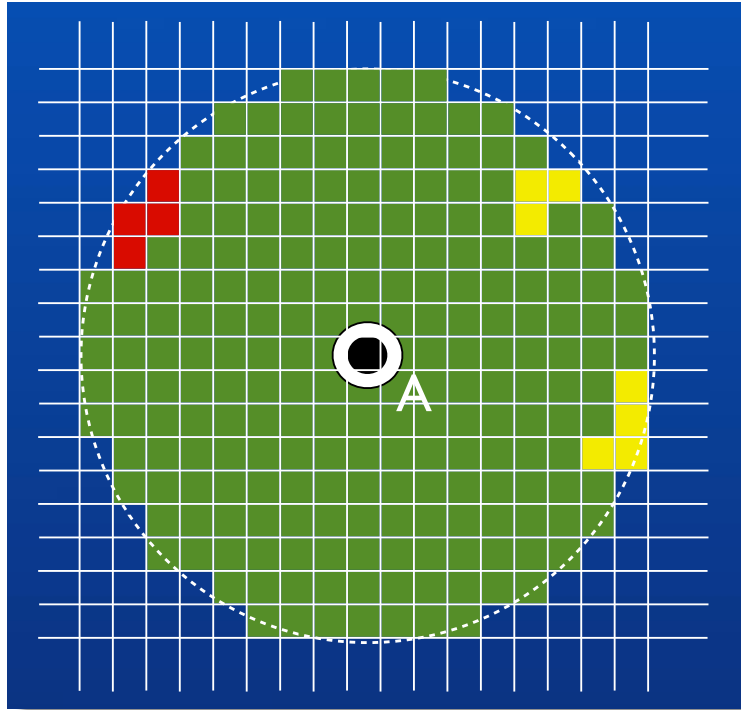
Green = coverage

Yellow = no coverage (e.g., terrain blockage)

Red = Interference



Assumptions for Coverage Area and Population Served



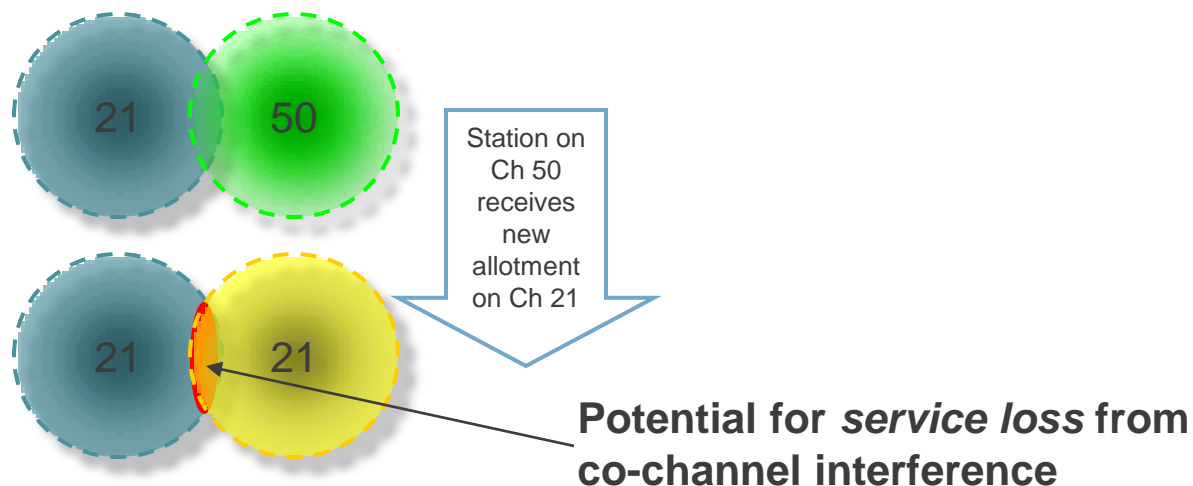
For purposes of satisfying the statutory requirement to make all reasonable efforts to preserve “coverage area” and “population served,” the Commission proposed in the NPRM to interpret:

Coverage area = noise limited contour w/o regard to interference
(the entire area inside the circle)

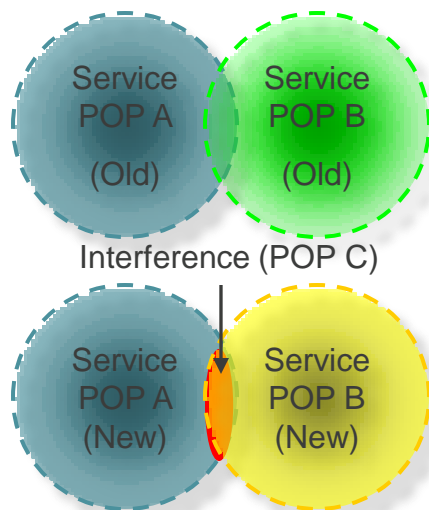
Population served = who receives signal within the coverage area, excluding station interference and terrain obstructions
(the green area)

FC Effect of Repacking

Channel Change



Service Impacts

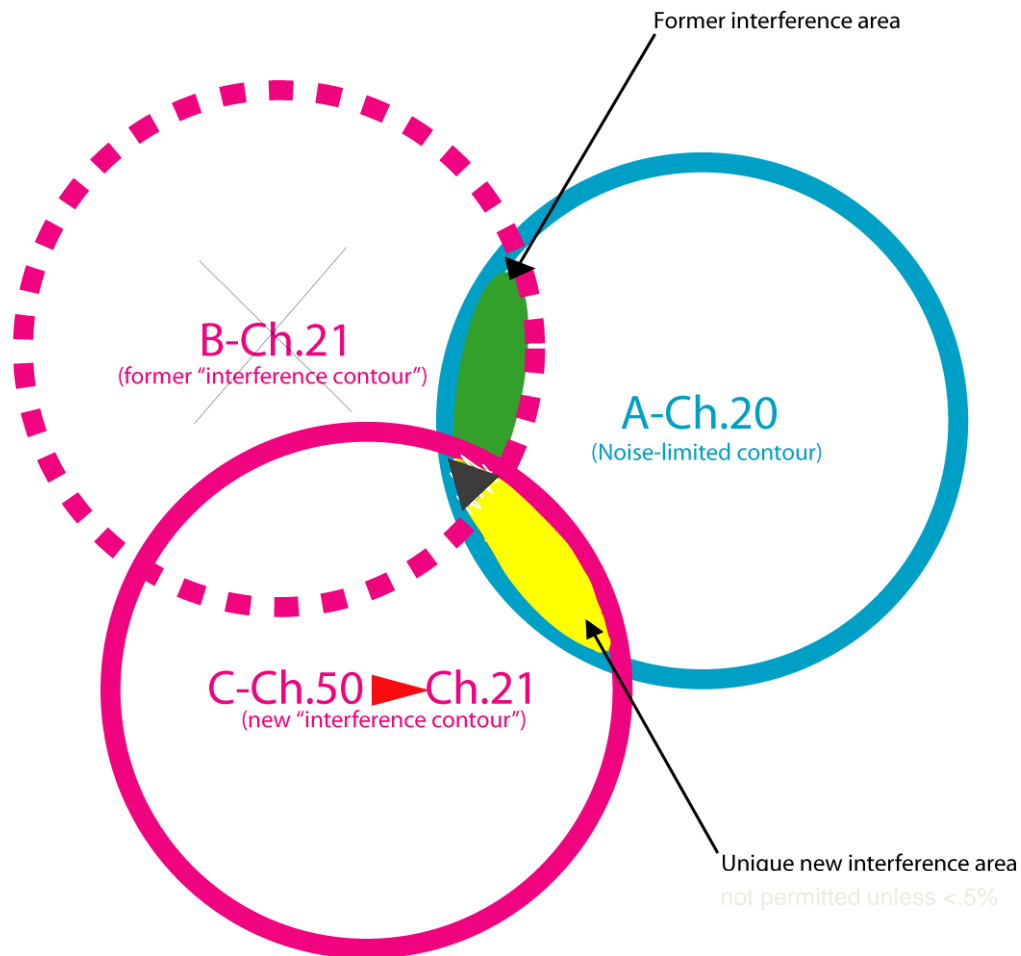


New interference must not reduce population coverage of either station by more than 0.5%



“Fixed” Option to Preserve Population Served

- Repack can “replace” only population interference existing as of 2/22/12
- Potential to gain new viewers (green)
- Channel assignment not permitted if population served loss exceeds 0.5% (yellow)
- Predicted areas of no change (black)



What is *TVStudy*?

- Software implementing the methodology of OET Bulletin No. 69
- Software output can be used to predict which stations can be permitted on co- and adjacent-channels to other stations
- For example, if the “Fixed” interference option is adopted, existing areas of population interference cannot be moved
 - Requires bookkeeping of interference on a cell-by-cell basis – millions of cells
 - Because many TV stations are collocated (e.g., Sutro Tower), there may be many permutations that create the same geographic pattern of interference
- Using *TVStudy* to pre-calculate a truth table of channel relationships that would likely be permissible enables use of a “feasibility checker” at each step of the auction.



Station Selection for Illustrative Study

- Legislation specifies protection of U.S. stations operating as of 2/22/2012
 - Full-power and Class A stations only
- Agreements with Canada and Mexico specify analog and digital allotments, some of which are vacant, but must still be protected
 - Digital allotments are assumed built at maximum facilities and are allowed to cause interference to U.S. stations
 - Mexican analog allotments are similarly assumed to be at maximum power and height and allowed to cause interference
 - Canadian analog allotments are generally replaced by co-channel digital allotments and so are not included
- A number of non-discretionary cases not included in the above
 - See July 22, 2013 Public Notice for details



Parameter Selection for Illustrative Study

- The February 4, 2013 Public Notice sought comment on 8 Parameters not specified in OET Bulletin 69. The final decision will be made by the Commissioners, but choices for the illustrative study are:
- Census Data – 2010
- Terrain Data – 1 arc-second (USGS DEM)
- CDBS errors – correct data if obvious (DA, BT)
- Beam Tilt – use value in CDBS, if available, else 0.75°
- Depression angles – calculate from AMSL heights
- Census Block locations – full precision
- Grid system – global (uniform)
- kwx=3 warnings – assume coverage (no change)

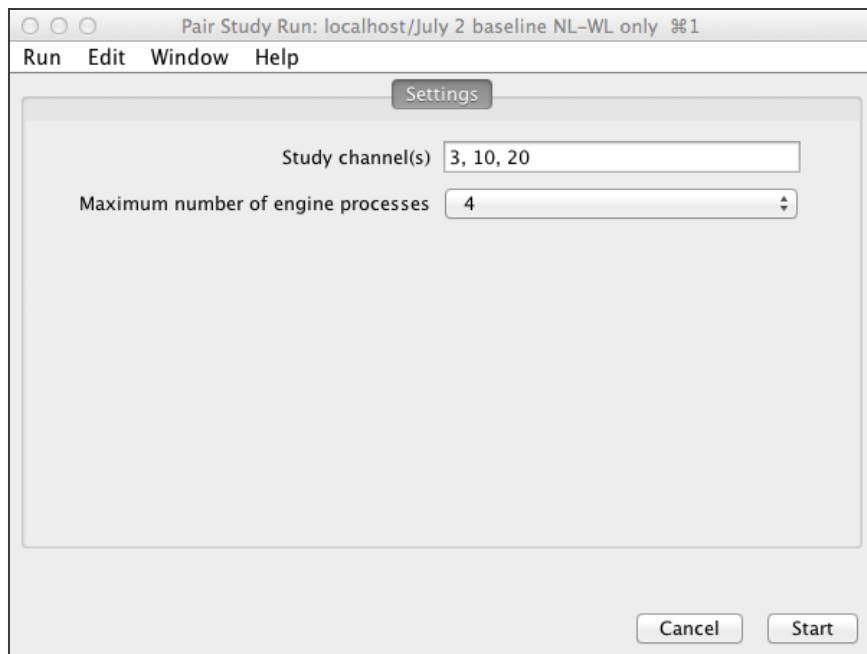


Sample Pairwise Output Files: “Truth Table”

- Pairwise output files from TVStudy can be combined in a relational way to determine whether a particular pair of stations might be assigned to a particular channel relationship in each television band.
- Sufficient data are provided to make this determination for any of the three options considered in the NPRM and for any desired “threshold” for acceptable interference.

Pairwise studies

- *TVStudy* can automatically replicate all U.S. stations onto user-selected channels (co- and ± 1) and calculate interference on each
 - For each channel selected, 3 interference scenarios are studied
- For compactness of output, one “proxy” channel per band was selected as shown below





Sample Pairwise Output Files

- An illustrative small study of just 13 stations
 - Took 34 seconds for baseline on 2.9 Ghz i7 Macbook
 - 15 seconds for 3-band pairwise study @ 2x2 km

Pair Study Run: localhost/small pair study 81

Run Edit Window Help

Settings Baseline Run 1 Run 2 Run 3 Post

```
0:00:00.000 - Log opened 2013.08.01 17:01:07.970
0:00:00.000 - Study open for studyKey=14
0:00:00.002 - Loading study sources
0:00:00.045 - Running preliminary source checks
0:00:25.815 - Replicating contours
0:00:31.506 - Updating database records.
0:00:33.045 - Updating caches.
0:00:33.374 - Begin run for scenarioKey=2
0:00:33.375 - Projecting contours and building undesired lists
0:00:33.380 - Starting global grid study
0:00:33.381 - Grid setup for 217555 225095 532884 546520
0:00:33.384 - Grid size 65 130 12180
0:00:33.384 - Pre-loading population for entire grid
0:00:34.001 - Cell setup for sourceKey=8 218465 221780 537636 543708
0:00:34.002 - Calculating fields in grid cell 62 of 12180
0:00:34.359 - Calculated 39560 new fields
0:00:34.359 - Updating caches
0:00:34.366 - Analyzing coverage
0:00:34.389 - Grid setup for 230360 236275 525016 539470
0:00:34.390 - Grid size 65 146 9009
0:00:34.390 - Pre-loading population for entire grid
0:00:34.680 - Cell setup for sourceKey=13 230945 235885 526417 538337
0:00:34.682 - Calculating fields in grid cell 140 of 9009
0:00:34.855 - Calculated 19048 new fields
0:00:34.855 - Updating caches
0:00:34.859 - Analyzing coverage
0:00:34.872 - Scenario run finished
0:00:34.876 - Study closed
```

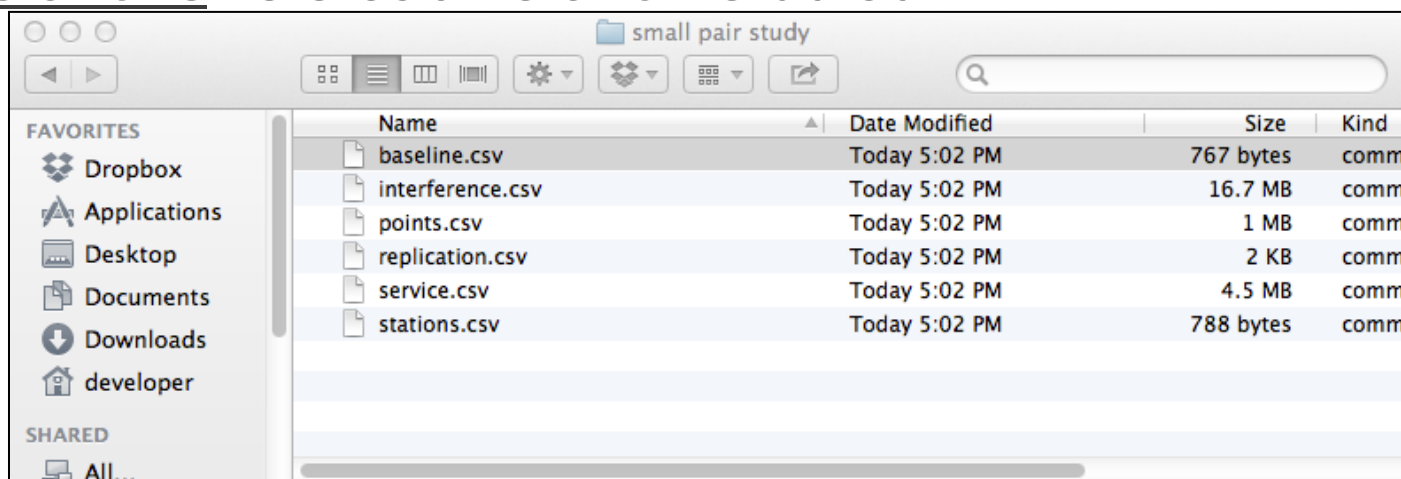
Study complete

Study complete

Cancel Close

FC Sample Pairwise Output Files; “Truth Table”

- Six files are created as shown below
 - baseline gives existing summary (total) coverage info
 - interference lists each cell with interference and the station pair involved
 - points lists details of each cell (pop, area, lat/long, etc.)
 - replication gives summary (total) coverage info on each replicated channel
 - service lists whether service or not for each cell
 - stations lists each station studied

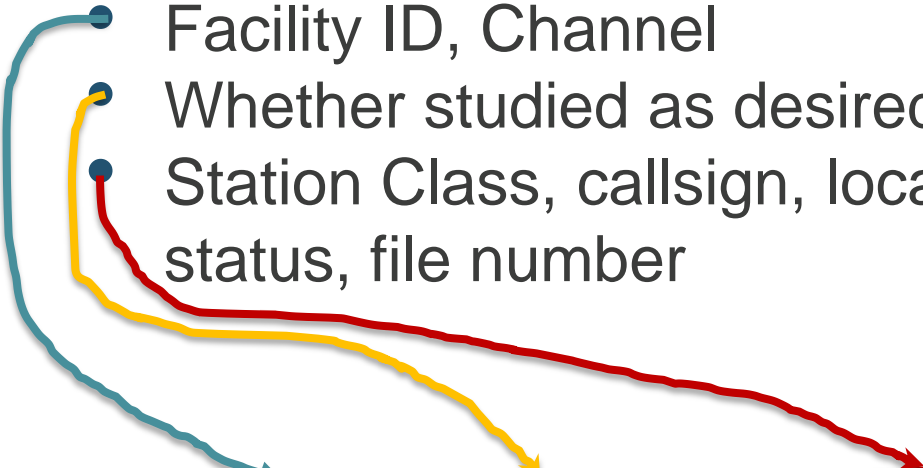


Name	Date Modified	Size	Kind
baseline.csv	Today 5:02 PM	767 bytes	comm
interference.csv	Today 5:02 PM	16.7 MB	comm
points.csv	Today 5:02 PM	1 MB	comm
replication.csv	Today 5:02 PM	2 KB	comm
service.csv	Today 5:02 PM	4.5 MB	comm
stations.csv	Today 5:02 PM	788 bytes	comm



Sample Pairwise Output Files: Stations

- Stations file is CSV format with high-level information on each station studied
 - Facility ID, Channel
 - Whether studied as desired and/or undesired
 - Station Class, callsign, location, country, authorization status, file number



	A	B	C	D	E	F	G	H	I	J	K	L
1	21488	5	1	1	DT	KYES-TV	ANCHORAGE AK		US	APP	BLCDT20110307ACV	
2	804	8	1	1	DT	KAKM	ANCHORAGE AK		US	LIC	BMLEDT20080325ADD	
3	10173	10	1	1	DT	KTUU-TV	ANCHORAGE AK		US	LIC	BLCDT20090619ABI	
4	13815	12	1	1	DT	KYUR	ANCHORAGE AK		US	LIC	BLCDT20090928AKO	
5	35655	20	1	1	DT	KTBY	ANCHORAGE AK		US	LIC	BLCDT20090608ABN	
6	49632	28	1	1	DT	KTVA	ANCHORAGE AK		US	LIC	BLCDT20061113AAT	
7	25221	33	1	1	DT	KDMD	ANCHORAGE AK		US	LIC	BLCDT20110106AAR	
8	787	35	1	1	DC	KCFT-CD	ANCHORAGE AK		US	LIC	BLDTA20121116ALD	
9	64597	7	1	1	DT	KFXF	FAIRBANKS AK		US	LIC	BLCDT20090129AMM	
10	69315	9	1	1	DT	KUAC-TV	FAIRBANKS AK		US	LIC	BLEDT20090929AJZ	
11	64596	13	1	1	DC	K13XD-D	FAIRBANKS AK		US	LIC	BLDVA20111128DAA	
12	13813	18	1	1	DT	KATN	FAIRBANKS AK		US	LIC	BLCDT20070403AAO	
13	49621	26	1	1	DT	KTVF	FAIRBANKS AK		US	LIC	BLCDT20090720ACS	



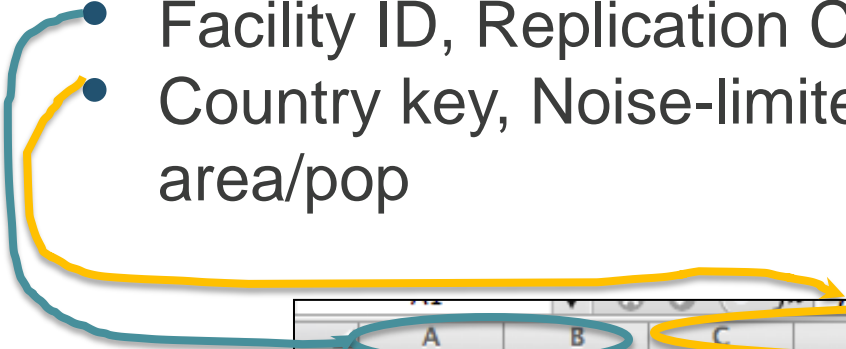
Sample Pairwise Output Files: Baseline

- Baseline file is CSV format with summary coverage information for each station studied
- Facility ID, Channel
- Country key
- Noise-limited area/pop, Terrain-limited area/pop, Interference-free area/pop

	A	B	C	D	E	F	G	H	I
1	21488	5	1	31860.247	392105	24420.07	388754	24420.07	388754
2	804	8	1	30451.906	380240	18958.659	376128	18958.659	376128
3	10173	10	1	30451.906	380240	18694.645	375991	18694.645	375991
4	13815	12	1	29471.714	379937	17882.492	375836	17882.492	375836
5	35655	20	1	9998.821	346300	7242.818	339547	7242.818	339547
6	49632	28	1	7455.719	341087	5892.969	337196	5892.969	337196
7	25221	33	1	11780.205	374951	7970.607	349244	7970.607	349244
8	787	35	1	6736.659	304383	5458.817	270048	5458.817	270048
9	64597	7	1	15533.456	98150	10913.465	97025	10913.465	97025
10	69315	9	1	24658.533	98716	17976.798	98027	17976.798	98027
11	64596	13	1	6832.435	97071	5143.439	94629	5143.439	94629
12	13813	18	1	11738.375	97261	6767.229	96280	6767.229	96280
13	49621	26	1	17287.725	98022	10801.122	95790	10801.122	95790

FC Sample Pairwise Output Files: Replication

- Replication file is CSV format with summary replication information for each station studied
 - Facility ID, Replication Channel
 - Country key, Noise-limited area/pop, Terrain-limited area/pop

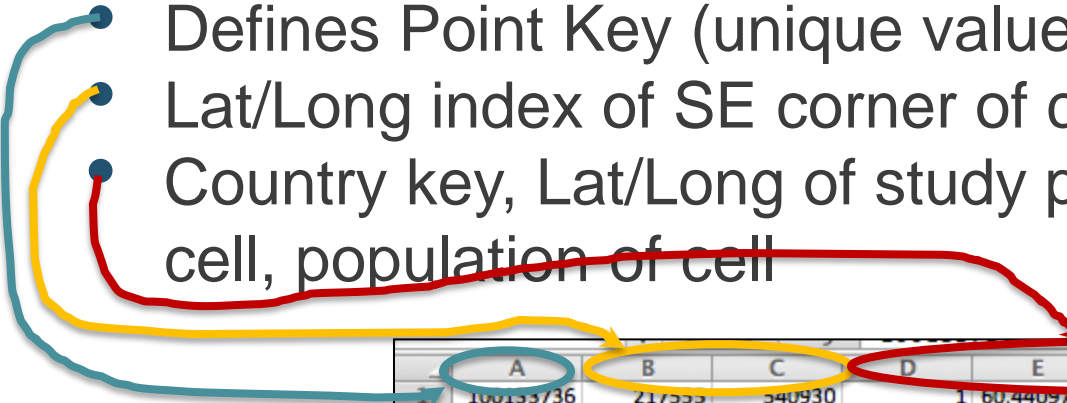


	A	B	C	D	E	F	G
1	787	3	1	6724.428	305593	6177.764	287421
2	787	20	1	6724.608	304383	5470.741	272352
3	787	10	1	6736.442	304873	5838.386	280167
4	49632	3	1	7458.097	347043	6982.652	346761
5	49632	20	1	7423.728	341087	5916.801	337674
6	49632	10	1	7434.477	346962	6164.044	343062
7	35655	3	1	9995.682	340779	8953.123	337970
8	35655	20	1	9998.821	346300	7242.818	339547
9	35655	10	1	10019.511	342584	7464.228	336157
10	21488	3	1	31735.996	391379	24959.846	388780
11	21488	20	1	31671.22	395418	18959.385	382092
12	21488	10	1	31665.202	392809	20143.979	385268
13	25221	3	1	11750.247	371413	10655.824	371313
14	25221	20	1	11708.153	374297	8380.114	358913
15	25221	10	1	11729.987	371409	9148.784	363227
16	804	3	1	30404.175	380080	23533.23	378186
17	804	20	1	30360.559	380074	17330.201	375958
18	804	10	1	30347.951	380240	18622.648	375991



Sample Pairwise Output Files: Points

- Points file is CSV format with common information about each cell studied
 - Defines Point Key (unique value for each study point)
 - Lat/Long index of SE corner of cell
 - Country key, Lat/Long of study point in cell, area of cell, population of cell

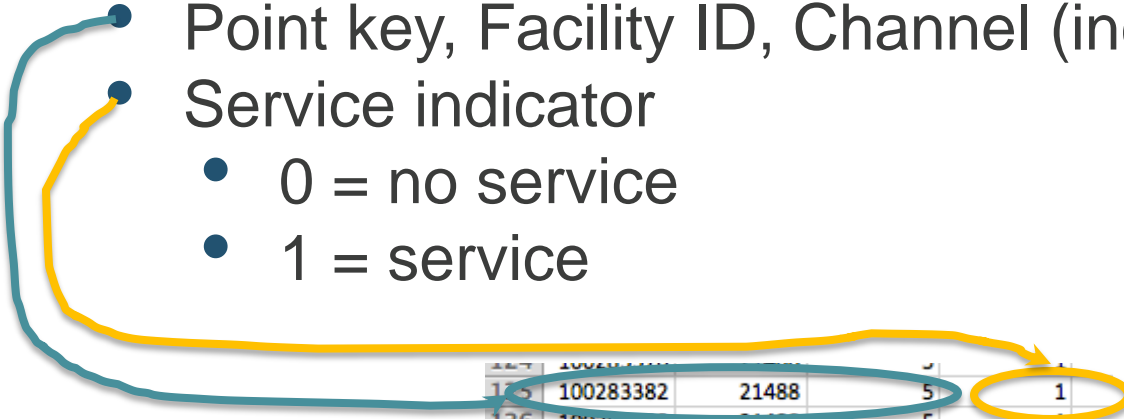


	A	B	C	D	E	F	G	H
1	100133736	217555	540930	1	60.4409722	150.276389	3.974843	0
2	100133742	217555	541060	1	60.4409722	150.3125	3.974843	0
3	100133748	217555	541190	1	60.4409722	150.348611	3.974843	0
4	100133754	217555	541320	1	60.4409722	150.384722	3.974843	0
5	100133760	217555	541450	1	60.4409722	150.420833	3.974843	0
6	100133766	217555	541580	1	60.4409722	150.456944	3.974843	0
7	100163622	217620	540410	1	60.4590278	150.131944	3.972635	0
8	100163628	217620	540540	1	60.4590278	150.168056	3.972635	0
9	100163634	217620	540670	1	60.4590278	150.204167	3.972635	0
10	100163640	217620	540800	1	60.4590278	150.240278	3.972635	0
11	100163646	217620	540930	1	60.4590278	150.276389	3.972635	0
12	100163652	217620	541060	1	60.4590278	150.3125	3.972635	0
13	100163658	217620	541190	1	60.4590278	150.348611	3.972635	0
14	100163664	217620	541320	1	60.4590278	150.384722	3.972635	0
15	100163670	217620	541450	1	60.4590278	150.420833	3.972635	0
16	100163676	217620	541580	1	60.4590278	150.456944	3.972635	0
17	100163682	217620	541710	1	60.4590278	150.493056	3.972635	0
18	100163688	217620	541840	1	60.4590278	150.529167	3.972635	0
19	100163694	217620	541970	1	60.4590278	150.565278	3.972635	0
20	100193511	217685	540012	1	60.4770833	150.021667	4.03151	0



Sample Pairwise Output Files: Service

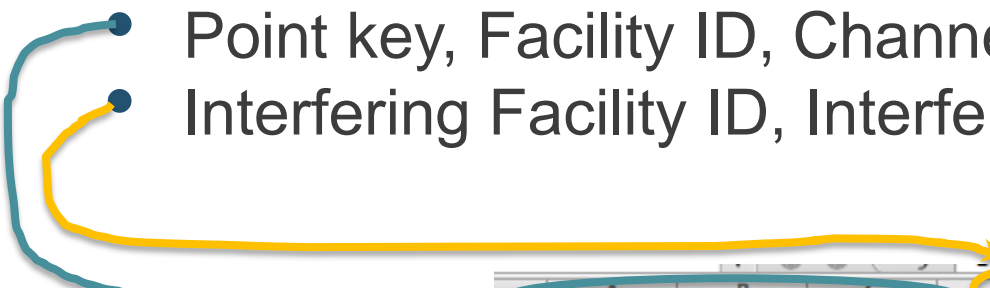
- Service file is CSV format with information whether there is terrain-limited service at each cell studied
 - Interference not considered
 - Point key, Facility ID, Channel (includes baseline)
 - Service indicator
 - 0 = no service
 - 1 = service



125	100283382	21488	5	1
126	100283388	21488	5	1
127	100283394	21488	5	1
128	100283400	21488	5	1
129	100283406	21488	5	1
130	100283412	21488	5	1
131	100283418	21488	5	1
132	100313097	804	8	0
133	100313097	10173	10	0
134	100313103	804	8	0
135	100313103	10173	10	0
136	100313109	21488	5	0
137	100313109	804	8	0
138	100313109	10173	10	0
139	100313115	21488	5	0
140	100313115	804	8	0
141	100313115	10173	10	0

Sample Pairwise Output Files: Interference

- Interference file is CSV format and lists only points with interference and station causing interference
- Point key, Facility ID, Channel (includes baseline)
- Interfering Facility ID, Interfering station's channel



	A	B	C	D	E
9	100642155	787	3	804	3
10	100642155	787	3	10173	3
11	100642155	787	3	13815	3
12	100642155	787	3	35655	3
13	100642155	787	3	49632	3
14	100642155	787	3	25221	3
15	100642155	787	3	804	4
16	100642155	787	3	10173	4
17	100642155	787	3	13815	4
18	100642155	787	3	35655	4
19	100642155	787	3	804	2
20	100642155	787	3	10173	2
21	100642155	787	3	13815	2
22	100642161	787	3	21488	3
23	100642161	787	3	804	3
24	100642161	787	3	10173	3
25	100642161	787	3	13815	3
26	100642161	787	3	35655	3
27	100642161	787	3	49632	3
28	100642161	787	3	804	4
29	100642161	787	3	10173	4
30	100642161	787	3	13815	4
31	100642161	787	3	35655	4



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Part II:

Generating Constraint Files

Brett Tarnutzer
Assistant Bureau Chief, WTB

[brett.tarnutzer @ fcc.gov](mailto:brett.tarnutzer@fcc.gov)

August 22, 2013

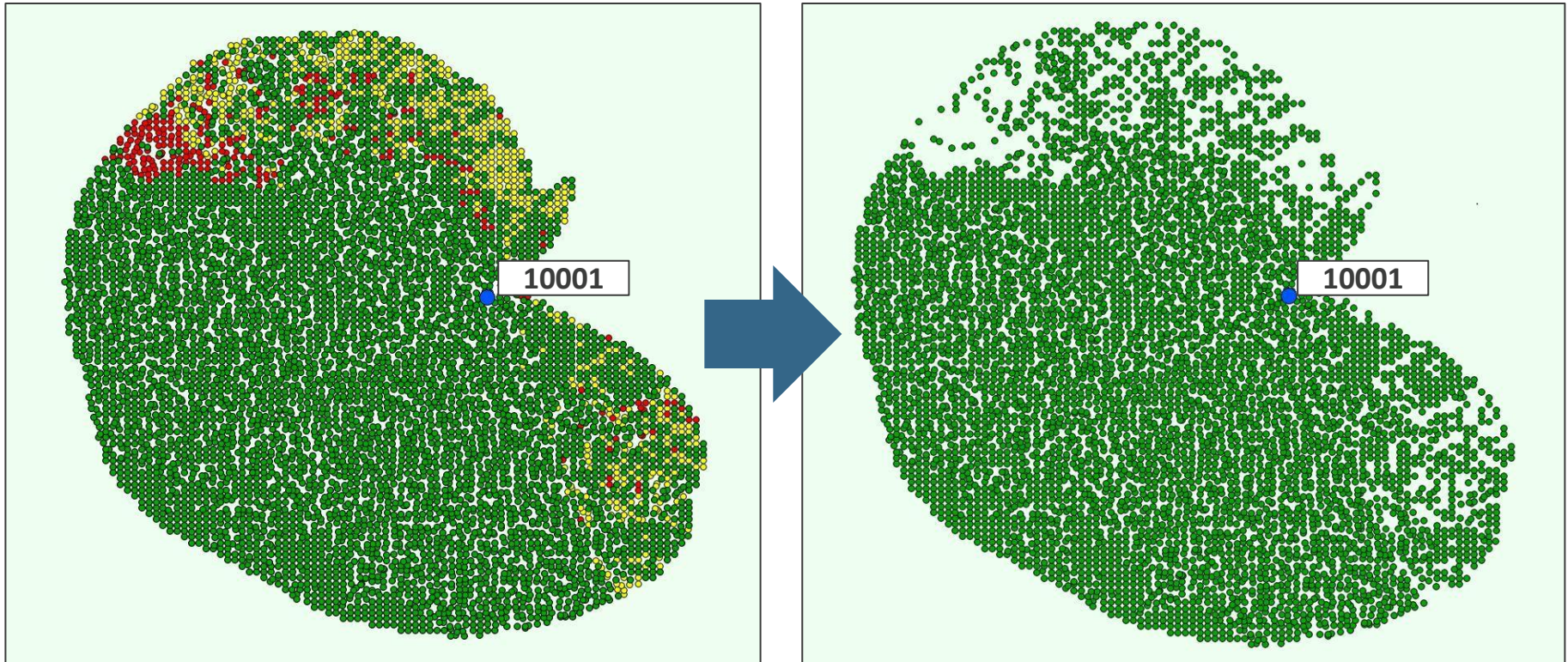


Constraint File #1: *Interference_Paired* File

- Illustrative example
- Following Option 2 (the “fixed” option preserving “population served”)
- Two key *TVStudy* output files used from:
 - *Service.csv*
 - *Interference.csv*



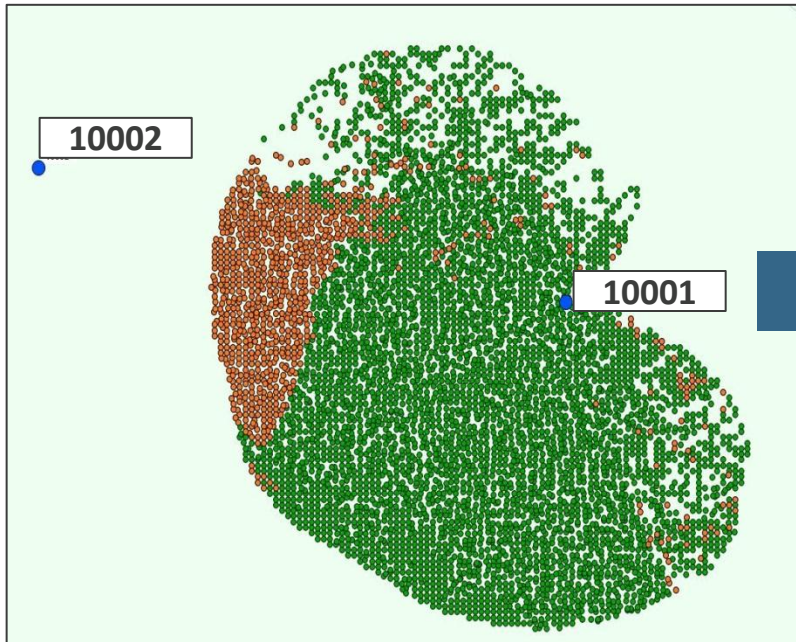
Step 1: Determine the “baseline” interference-free population of a station



BLUE = Station location;
GREEN = Original interference-free population;
YELLOW = Population with no service due to terrain;
RED = Population with no service due to interference.



Step 2: Replicate on proxy channels and count the number of new points of interference



BLUE = Station location;

GREEN = Original interference-free population;

ORANGE = Interference caused by Station 10002.

	pointkey integer	facilityid integer	channel integer	Interfering facilityid integer	Interfering channel integer
1	59899596	10001	3	10002	3
2	59929509	10001	3	10002	3
3	59959419	10001	3	10002	3
4	59989329	10001	3	10002	3
5	60019239	10001	3	10002	3
6	60049149	10001	3	10002	3
7	60049152	10001	3	10002	3
8	60079041	10001	3	10002	3
9	60079059	10001	3	10002	3
10	60079062	10001	3	10002	3

From the interference table, Station 10001 (on proxy channel 3) receives co-channel interference from Station 10002 (also on channel 3) in the ten cells indicated.



Step 3: Determine whether the new pairwise interference is predicted to exceed the 0.5% threshold

- *Sum of Population of Interference Points for Station 10001 on proxy channel 3 caused by Station 10002 = 180,844*
- *Baseline Interference-Free Population for Station 10001 on current Channel = 1,709,743*
- *Percent of Baseline Interference-Free Population impacted by this potential assignment = $180,844 / 1,709,743 = 10.58\%$*



Since 10.58% is $> 0.5\%$,
Station 10001 on proxy channel 3 cannot exist with
Station 10002 also on channel 3.



New constraint is added to the *Interference_Paired* file

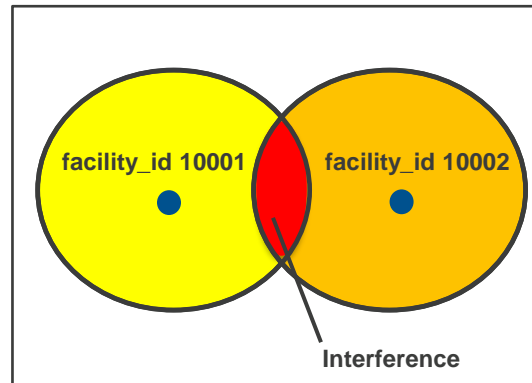


Step 4: Repeat for Each Station Pair Within Culling Distance to Create “Truth Table”

4.a. Generate Station Pairs*

Station1	Proxy Channel	Station2	Channel2
10001	3	10002	2
10001	3	10002	3
10001	3	10002	4
10001	10	10002	9
10001	10	10002	10
10001	10	10002	11
10001	20	10002	19
10001	20	10002	20
10001	20	10002	21

4.b. Run *TVStudy*



4.c. Perform Post-Processing

4.d. Generate Results

Station1	Proxy Channel	Station2	Channel2	% POP
10001	3	10002	2	0.47
10001	3	10002	3	10.58
10001	3	10002	4	0.85
10001	10	10002	9	0.33
10001	10	10002	10	8.21
10001	10	10002	11	0.66
10001	20	10002	19	1.31
10001	20	10002	20	10.39
10001	20	10002	21	1.43

*NOTE: 2177 Stations in the U.S. excluding territories



Step 5: Generate *Interference_Paired* File

If after repacking **Station 10001*** is placed in the UHF band (**channels 14-51**) then:

- a) Stations **1116, 1301, 285, 1356, 390, 588, 1981** and **383** cannot be placed on the same channel (co-channel);
- b) Stations **1116, 1301, 285, 1356, 1981** and **383** cannot be placed on the first adjacent channel above station **10001**;
- c) Stations **1116, 1301, 285, 1356, 1981** and **383** cannot be placed on the first adjacent channel below station **10001**.

CO,	14,	51,	10001,	1116,	1301,	285,	1356,	390,	588,	1981,	383
ADJ+1,	14,	51,	10001,	1116,	1301,	285,	1356,	1981,	383		
ADJ-1,	14,	51,	10001,	1116,	1301,	285,	1356,	1981,	383		

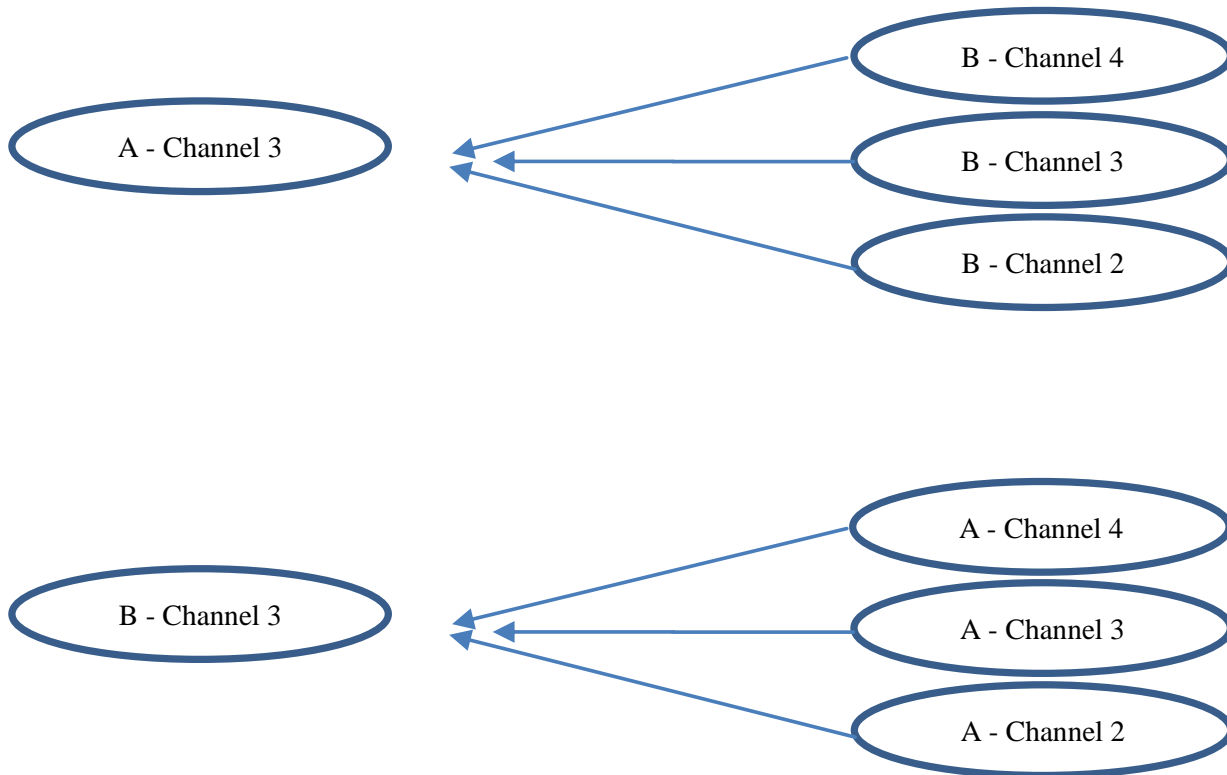
**Sample – does not reflect real station data.*



Nuance – Asymmetry

“Protected Station”

“Interfering Station”





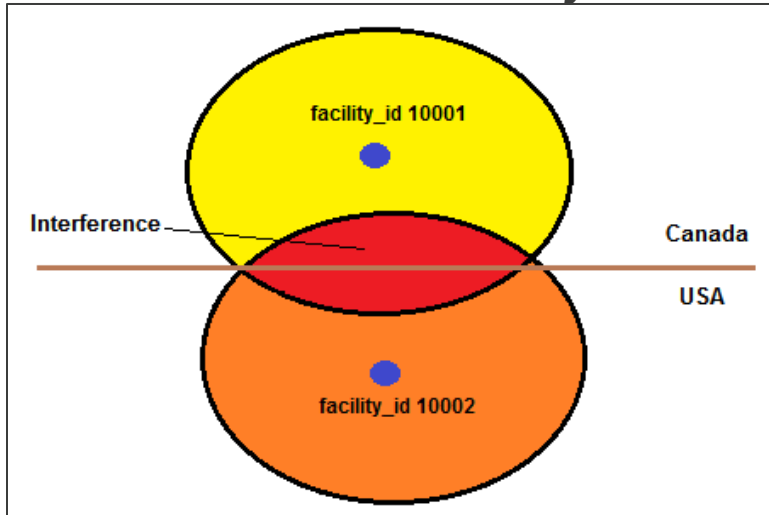
Constraint File #2: *Domain File*

- Illustrative example
- Dealing with “fixed” constraints:
 - Canadian allotments
 - Mexican allotments
 - LM and LMW stations
 - Channel 37
 - ORTS



Step 1: Protecting Canadian Allotments

1.a. Run *TVStudy*



1.b. Generate Results

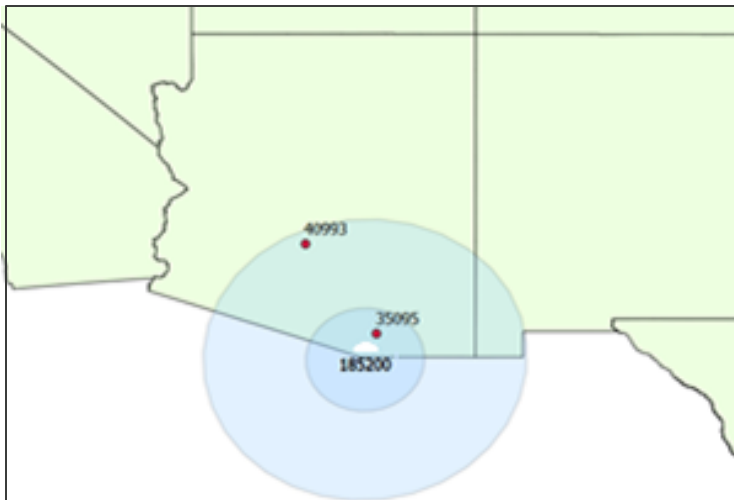
Desired: Canadian Station	Channel (Canada)	Undesired: USA Station	Channel (USA)	% POP
10001	43	10002	42	0.55
10001	43	10002	43	5.26
10001	43	10002	44	0

- Assumed Canadian allotments remained on their existing channel
- Run *TVStudy* putting “undesired” U.S. stations on actual Canadian allotment channels
- U.S. Stations which violate the 0.5% threshold have a channel removed from their domain in the *Domain file*



Step 2: Protecting Mexican Allotments

2.a. Map Border Stations



2.b. Determine Exclusion Zones Based on Relevant Distance Separations

US and Mexico Operations	DTV to DTV Station	DTV to NTSC Station
Co-Channel VHF:	273 km	273 km
1 st Adj. Channel VHF:	48-96 km	18-100 km
Co-Channel UHF:	223 km	244 km
1 st Adj. Channel UHF:	32-88 km	10-88 km
± 2 UHF:	-	24-32 km
± 3 UHF:	-	24-32 km
± 4 UHF:	-	24-32 km
± 7 UHF:	-	24-95 km
± 8 UHF:	-	24-32 km
+ 14 UHF:	-	24-95 km
+ 15 UHF:	-	24-96 km

- Assumed Mexican allotments remain on their existing channel
- Distance-based protections



Step 3: Protecting Land Mobile

3.a. Map LM City Centers and LMW Base Stations



3.b. Determine Exclusion Zones Based on Relevant Distance Separations

US and Land Mobile Operations	DTV to Land Mobile (LM) City Center	DTV to LM Waiver (LMW) Base Station
Co-Channel:	250 km	185 km
Adjacent Channel:	176 km	96 km

- Assumed LM and LMW operations remain on their existing channel
- Distance-based protections
- Protect from LM City Centers and LMW Base Stations



Step 4: Protecting Channel 37 and Other Applicable Radio Services

- Assumed no station could be placed in Channel 37
 - Reserved for RAS and WMTS



- Assumed no applicable restriction on repacking from ORTS (“Offshore Radiotelephone Services”)
 - But we do add a constraint to protect Channel 17 in Hawaii for point-to-point inter-island communications



Step 5: Generate *Domain File*

In the following sample, **Station #10001*** may only be placed on **channels 2, 3, 4, 5, 6, 19, 20, 21, 48, 49, 50, 51**. A channel assignment algorithm could not place **Station #10001** on any other channel.

DOMAIN, 10001, 2, 3, 4, 5, 6, 19, 20, 21, 48, 49, 50, 51
--

**Sample – does not reflect real station data.*

Use of Constraint Files and Associated Data

- Verify Commission data
- Generate constraint files using other assumptions
- Explore conducting repacking analyses based on assumptions about which stations stay on the air and are assigned channels in the incentive auction repacking process



THANK YOU



Reference Information

- TVStudy and documentation
<http://data.fcc.gov/download/incentive-auctions/OET-69/>
- List-serve for discussion and announcements
AFCCE-CDBS@cavell-mertz.com
- Questions
Mark.Colombo@fcc.gov
Robert.Weller@fcc.gov
- General Incentive Auction Information:
Visit the FCC Learn Website
(<http://wireless.fcc.gov/incentiveauctions/learn-program/>)
- Incentive Auction Questions:
brett.tarnutzer@fcc.gov
learn@fcc.gov